Quaternary International 435 (2017) 144–163

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Did stones speak about people? Flint catchment and Neanderthal behavior from Area 3 (Cañaveral, Madrid-Spain)

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ARTICLE INFO

Article history:
Available online 9 February 2016

Keywords:
Quarrying
Mousterian
Operative chain
Refits
Intra-site analysis

ABSTRACT

Middle Paleolithic catchment patterns have been exhaustively studied in the past. However, it is essential to clearly define Neanderthal technical and strategic abilities in relation to raw materials self-provide, from a temporal perspective. Here we present a study of quarrying activities in open air sites occupied during Mousterian period in Madrid (Spain), with different patterns of lithic catchment. At the El Cañaveral archaeological complex, several sites have been identified, in relation with natural flint outcrops. From these we have gained information about flint supplying patterns, both in primary and secondary deposits. In addition, different "operative chains" and diverse systems of ramification and recycling were employed depending on the final objectives. We were able to appreciate additional actions by analyzing the diacritic superposition of knapping series in blanks, cores and supports of different qualities. Changes in categories, dimensions and raw material qualities, allow a first identification of lithic actions throughout time as a proxy of standardized or random human behavior when catchment actions took place.

1. Introduction

The research of raw material supply during middle Paleolithic has been very prominent in recent years. These analyses provide important information not only about the quarrying sites and their contexts, but also about the organization capacities of groups, their economic necessities and technological aptitudes to solve them (Terradas, 2001).

In the middle Paleolithic period, settlements are not directly linked to raw material quarrying sites but normally *to* open-air places. In addition, supply strategies, transformation processes, use and abandon are more complex than during previous periods. This could be because there is more circulation and selection of raw material, the knowledge of the territory is greater than before and knapping techniques are also more complicated (Barquín and Sanguino-González, 1998; Conde Ruiz et al., 2000; Mangado, 2006).

El Cañaveral archaeological site (Madrid, Spain) is an open air raw material quarrying site, which was occupied during the middle Palaeolithic period. It was discovered thanks to research projects supported by the Consejería de Empleo, Turismo y Cultura in the Madrid region. Later excavations conducted by Arquex SL, an archaeological company, and the UAM research team determined different aspects of the site formation and its human occupation (Baena Preysler et al., 2008a).

Initially, a survey excavation was carried out and, following the discovery of a large number of lithic industries associated with raw material blanks, an open excavation in different areas was started. One of the main zones was Area 3, covering a total of 164 m^2 with 14,958 coordinated lithic pieces (flint) in two different levels (91.2 pieces/m^2), but apparently there were no faunal remains even if preservation was possible.

This sequence included at least one clay layer with large assemblages of lithic industry represented by an abundant number of cores, flakes and hammerstones. During the excavation the distribution of oval or circular concentrations of fresh material was recovered, corresponding to particular *debitage* areas as well as hearth remains indicating a temporary occupation of this area (Baena Preysler et al., 2011). According to the remains, this site represents a palimpsest of different occupations, but it is possible to establish some specific activity events.

There were materials interchanged between concentrations with mostly horizontal layouts and sets of raw materials located along vertical slopes, which are the result of the edaphic processes that took place later. New coluvionar-eolic episodes had a low

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http://dx.doi.org/10.1016/j.quaint.2016.01.019
1040-6182/

impact on the distribution of various knapping zones with the partial dragging of some pieces and the intrusion of new boulder materials (Baena Preysler et al., 2011; Machado et al., 2011).

On one hand, it is possible to establish a hiatus that shows differences between two layers (Level II and Level III). Those levels are deposits formed by anthropological processes (knapping activities) and sedimentary processes, both factors that could cause the presence of a palimpsest characterized by spatial accumulations of sporadic knapping processes in the same place, but in different events (Bailey, 2007; Machado et al., 2011; Malinsky-Buller et al., 2011).

On the other hand, however, several refits were discovered inside concentrations, some between them and others between different levels. This could mean that the burial process of the site occurred relatively quickly and with minimal geological disturbances.

According to Area 3 remains, lithic supply activities could vary throughout time (different periods) and depend on the needs of the group (flint nodules, cores or supports), also on the distance to the quarrying site from the settlement, or on the discrimination of different types and qualities of raw material.

So, the aims of this paper are to define and explain the different operative chains documented on level II of Area 3, from the initial phases (raw material catchment methods) until the abandon phase and to relate them *to the* behavioral patterns of Neanderthal groups. There are different ramifications inside the reduction sequence produced by recycling processes that make this more complicated. At the same time we will try to establish different occupation patterns and phases occurring on level II using technical and technological means.

2. Geological background

The archeological site “El Cañaveral” is located in Madrid, on the central plateau of the Iberian Peninsula (Spain). Its geological context is the Madrid basin, which is part of a bigger morphostructural unit called the Tajo Basin. It has a triangular shape and is bounded by the Central System and the Gredos mountains in the North West, by the Iberian Range in the North East, and by the mountains of Toledo in the South (Pérez-González, 1994; Uribelarrea Del Val, 2008).

During the Miocene period, the basin underwent changes caused by various factors which led to three large stratigraphic units: the Lower Unit, the Middle Unit and the Upper Unit (Baena Preysler et al., 2011).

In the project area, the Miocene stratigraphic series is represented by the Lower Unit, made up of gypsums with green clay intersections. The Intermediate Unit is made up of clays, dolomites and flint levels. This intermediate Unit is divided into two additional layers: the Lower component, and above it, the Upper component, made up of sharp folder clays with some carbonates and flint nodules (Bárez and Pérez-González, 2007)

With regards to its geomorphology, the main characteristic features of this area have been controlled mainly by lithology and climatic factors. It has two distinct domains, the Jarama Valley in the East, and the erosive-structural plains in the West. The wide Jarama Valley presents great asymmetry with many stepped terraces on the left bank and a strong erosive character on the right bank. The western boundary of the valley is characterized by cliffs formed from gypsum (Baena Preysler et al., 2011).

On the top of the cliffs, from the right bank of Jarama to the cliffs on the left of the Manzanares, there is a plateau which forms part of the great dividing platform situated between these two rivers. It is a relief of structural-erosive origin conditioned by the presence of flint layers and carbonated clays (Baena Preysler et al., 2008a). The archeological site “El Cañaveral” is situated on a platform that defines the watershed between the Manzanares and Jarama rivers, where many silica rocks (such as flint and opals) have come to the surface due to different erosive processes. The unusual abundance of theses rocks explains the presence of a large number of archaeological sites linked to the supply/catchment patterns of raw materials.

Siliceous rocks on this area are characteristics from Madrid basin, formed by replacing other sedimentary rocks that filled the basin (silcretes). As a consequence of this replacement (silicification) siliceous rock with nodules were created with lenticular and

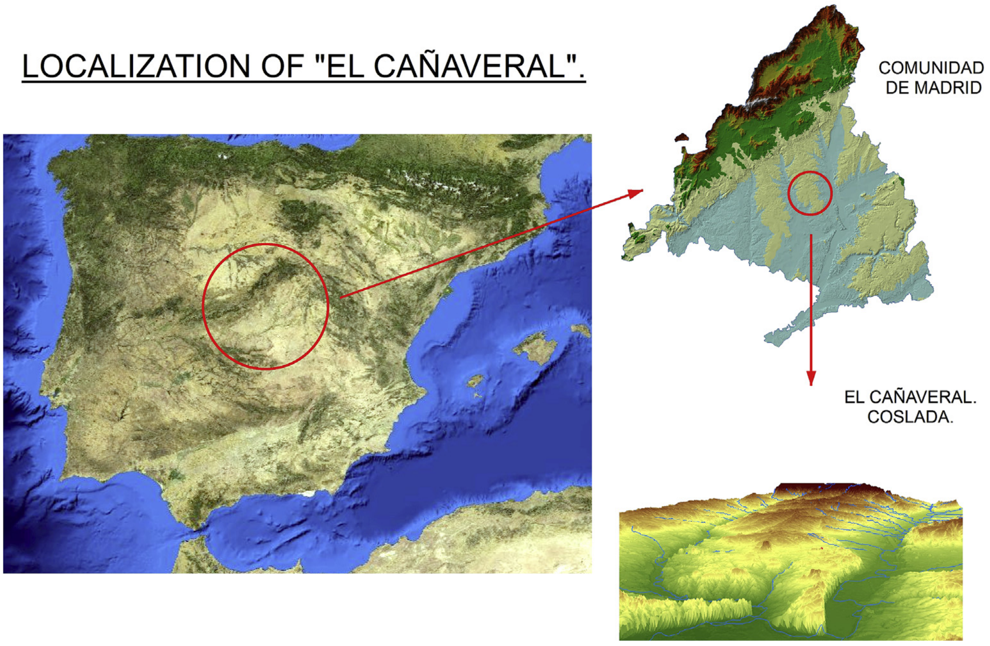

Fig. 1. Localization map of El Cañaveral, Madrid, Spain.

Fig. 2. Area 3 during excavation process.

irregular morphologies. Mineralogy studies show that the majority of the siliceous properties of these rocks comes from quartz, and a small percentage from clays and feldspars (Bustillo et al., 2012).

Some evidence of the existence of a wide quaternary sedimentary series in the whole area was recovered. These are of colluvium sediment, of fluvial and eolian origin. The thickness varies because of the high quaternary karstic activity in the Lower Unit of Miocene. This activity caused deformations in the Intermediate Unit and the presence of subsident areas in the surface where all sediments are adapted (Baena Preysler et al., 2011).

The preservation of a large number of archaeological sites, such as Area 3, has been made possible by diverse sedimentary stages, both eolian and colluvial, which occurred during this quaternary period. The lacked high energy and almost any transport capacity that rapidly covered and buried the anthropological activities has protected them from external erosive agents (Baena Preysler et al., 2011, 2008b) (Fig. 1).

3. Area 3, El Cañaveral

Area 3 had provided a sequence of three different levels with two TL dating results for the top and bottom, similar to the rest of the excavated areas (level II sample ref.CAN41. 33.0 + 4.0/−3.5 ka; level III ref.CAN42. 96 + 34/−21 ka) (Fig. 2).

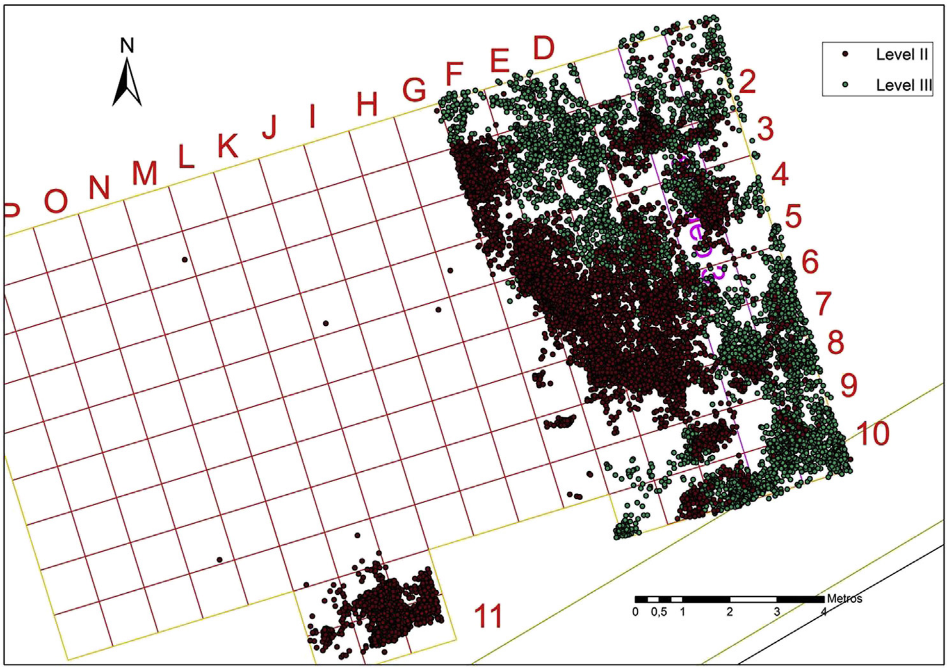

Fig. 3. Distribution map of Level II and Level III pieces.

The distribution of the materials alternates between concentrations with predominantly horizontal layouts and sets of raw materials located along vertical slopes, which are a result of the edaphic processes that took place later. At the same time, it is likely that the colluvionary deposits were the principal source of raw materials and the basis upon which the well-preserved traces of knapping activity were superimposed. New coluvionar-eolic episodes affected the distribution of various knapping zones in different ways, with the partial dragging of some pieces and the intrusion of new boulder materials (Fig. 3).

The first stages of the operative chain in Area 3-El Cañaveral have been recognized. Procurement, reduction and blank production aimed at the exploitation of the materials, together with steps to full production, took place within the same space. Traces of consumption activities, the final stages of the operative chain, were very limited, indicating that human occupation was of a short duration (Baena Preysler et al., 2011).

4. Material and methods

A total of 14,958 coordinated pieces were found in 164 m^2. During the excavation process, 3 levels were identified: Level II, Level II–III and Level III. We are currently studying Level II and II–III together. There are various reasons for linking them both, such as the technological similarities of pieces, the same type of alterations and refits between levels. For these reasons we decided to study these two levels together to confirm their homogeneity (Ortiz Nieto-Márquez, 2013) (Table 1).

Table 1
Lithic categories of Level II/II–III.

Categories	N° pieces
Flakes	3024
Cores	202
Fragments	1432
Hammerstones	18
Tools	23
Nodules	180
Total studied	**4879**
Total Level II/II–III	**8142**
Studied	**60%**

For this paper it has been studied a representative sample of the whole complex (60%), because of the high number of pieces (n = 8142), from these 2 levels. We worked with 3024 flakes, 202 cores, 1432 fragments, 18 hammerstones, and 23 tools from these 2 levels as well as 180 nodules.

The way to analyze operative chains (Geneste, 1985) is to divide them into different aspects, such as the replication of reduction sequences (experimentation), the refitting of the products of core reductions, the analysis of scar patterns and/or technological classification. With the exception of replication, we have used the rest of the procedures to identify and analyze the different operative chains documented in Area 3.

To make a classification, we have applied an Attribute Analysis System, which gives a technical projection to defined attributes, liking all of them to a determined gesture of production intention (Carrión Santafé, 2002).

In this case we have made a categorical distinction between Cores, Cortical flakes, Non-cortical flakes, Fragments, Nodules, Tools and Hammerstones. We have measured the majority of pieces and also we have noted the weight of cores, hammerstones, and nodules.

Focusing on flakes, we measured them and analyzed the sort of percussion platform, differencing flat, dihedral, faceted and crushed ones.

For the study of cores, we measured them and their weight, counted the numbers of removals and measured the last of these. The core's support type was also documented, as nodules, flakes, or fragments. Finally, we also analyzed some knapping mistakes as hinge flakes, stepped scars concentrations, and sleeping percussion cones.

This information is very useful if we can relate it to technological studies. Current technological studies should understand and analyze a great part of all lithic categories, evaluating the complementarity and coherence and determine the ultimate finality of the knapping process. The aim of this is to restore, with a dynamical perspective, the global technological process (Baena Preysler and Cuartero, 2006).

In this case we made a technological reading, where we analyzed all artefacts to identify the different techniques and knapping methods used in Area 3. We identified Levallois and Discoidal methods and some Expeditious, Polyhedral, and “irregular” cores. It was documented thanks to the study of the core's scares and the analysis of flakes and tools.

According to the traditional definition of Levallois method used by Bordes and Boëda (Boëda, 1988, 1990, 1993, 1994; Bordes and Bourgon, 1951; Bordes, 1980, 1961) among others, as a “close methodology of exploitation cores to obtain predetermined flakes”, some varieties have been recorded along the time and sites. Some of them have been documented in Area 3 remains, like different uses of cores convexities and their reconditioning processes (Delagnes, 1990; Pigeot, 1991; Grimaldi, 1998) and faceted and non-faceted platforms in predetermined flakes (Slimak, 2008; Hérisson, 2012; Goval et al., in press). Our study includes other elements to widen and amplify the methodology since some reductions do not present a real canonical platform preparation in all of the obtained flakes.

The analysis of dorsal scar patterns on lithic is considered a methodological development (Bar-Yosef and Van Peer, 2009). We have carried out a diacritic analysis (Baena Preysler and Cuartero, 2006) in some cores when it was no possible to refit them. This method provide us important information about different exploitation stages of cores, diverse methods used as well as different mistakes during knapping processes or purposes.

Refitting is a superior analytical tool to analyze operative chains because it portrays the different and successive phases of the reduction sequence (Bar-Yosef and Van Peer, 2009). The problem is the limited potential of the majority of Paleolithic assemblages for reconstruction through refitting.

Since 1987, E. Cziesla had defined 3 types of refits, depending on the reason of the fracture: reduction sequence refits, fracture refits and second modification sequence refits (Cziesla, 1987). Afterwards, some new refits have been included, including thermal fractures refits and natural fractures ones (Cattin, 2002; Loecker et al., 2003; De la Torre et al., 2004).

We have been looking for refits in Area 3, and we have found some of them. For this paper we have used reduction sequence ones to explain different operative chains documented on the site, and fracture refits to document some mistakes involved in sequence reduction. There are joins of flakes that show some special exploitation strategies, and some refits of flakes and cores where it was almost possible to reconstruct the whole nodule. On the other hand, there are refits that show some considerable mistakes took place during knapping phases, in contrast to some reduction sequences refits characterized by perfect actions. This could show some skill levels involve in knapping activities (Hovers, 2009).

5. Results

5.1. Raw material catchment

The first phase of the *operative chain* is raw material catchment. Area 3 is an open-air raw material quarrying site, where raw material was provided by big flint nodules situated on surface. Different groups who visited this site used these nodules to supply their needs for knapping activities.

There are 180 nodules situated on surface of levels II and II–III. All of them are of the same raw material (Miocene flint), but there are differences between qualities (miscellaneous flint formation homogeneity, presence of geodes, internal fractures …). We measured and made note of the weight and counted the number of knapping negatives they have.

As it is possible to see in the graph below, most of nodules measure between 5 and 15 cm width and 5 and 20 cm in length, although some of them are bigger. This size is suitable to start knapping or at least to check flint quality. They abandoned nodules whether they recognized poor quality or some flint mistakes (geodes, internal fractures …) (Fig. 4).

Weight was also documented. The heaviest nodule was 14.5 kg and the lightest 29 g. The overall average is almost 2 kg per nodule, a suitable weight also to transport or knap them *in situ* (Table 2).

Table 2
Nodules weight.

Nodules weight	
Maximum	14.5 kg
Minimum	0.029 kg
Average	1969 kg

Finally, we counted the number of removal scars, and the maximum of 9 removals and the minimum 1, with some nodules showing no signs of removal. The average number is 3, normally with a unipolar or orthogonal direction. This kind of removal show how knappers were testing flint quality (Table 3).

Table 3
Number of removals.

Number of removals	
Maximum	9
Minimum	1
Average	3

In the figure below it is possible to see coordinated nodules distribution in Area 3. There were some concentrations in the south. In the extension area (from G column to Q) all pieces were only documented in pictures, and there were some big nodules surrounded by small pieces, suggesting evidence of knapping (Fig. 5).

Two kinds of raw material catchment were documented. The first was direct catchment, where the population took the whole nodule to start knapping. The second was testing nodules, where people checked flint quality (Fig. 6).

These testing actions were made by quartzite hammerstones as we will see later (possibly coming from Jarama basin, 4 km away) and by some nodules and flint fragments used as hammerstones or anvils. Some flint artifacts showed large crushed areas, which indicated that they had been used to strike other flint nodules. Later we will show more detailed information about possible recycling activities in Area 3 (Fig. 7).

5.2. Exploitation stage

For this second phase of the *operative chain*, where cores started to be configured and exploited, we have studied 202 cores. Different technologies are documented thanks to the attributes analysis system, technological approach, refits and diacritic analysis. As the table shows, there are 34 Levallois cores, 12 Discoid, 12 Polyhedron, 65 expeditious and 79 “irregular” ones (Table 4).

Table 4
Cores technology.

Cores	No.
Levallois	34
Discoid	12
“Expeditious”	65
Polyhedron	12
Irregular	79
Total	**202**

Each core was analyzed. We have documented their measurements, weight, kind of support, and each removal was counted, and the size of the last one was documented. In the table below, we show the different kinds of support depending on technological chance. Most Levallois and Discoids cores are made from flakes. On the other hand, most polyhedron cores used fragments as supports. Finally, expeditious and irregular ones used flakes and fragments at

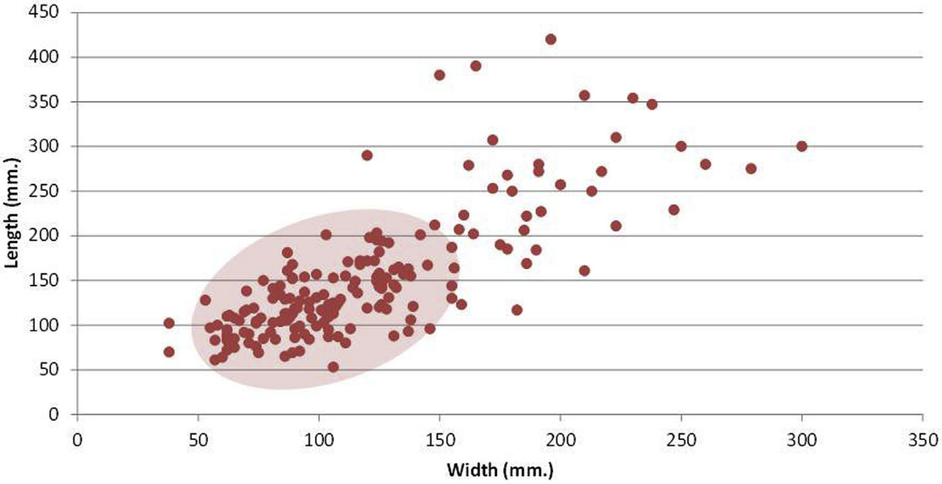

Fig. 4. Nodules measurements.

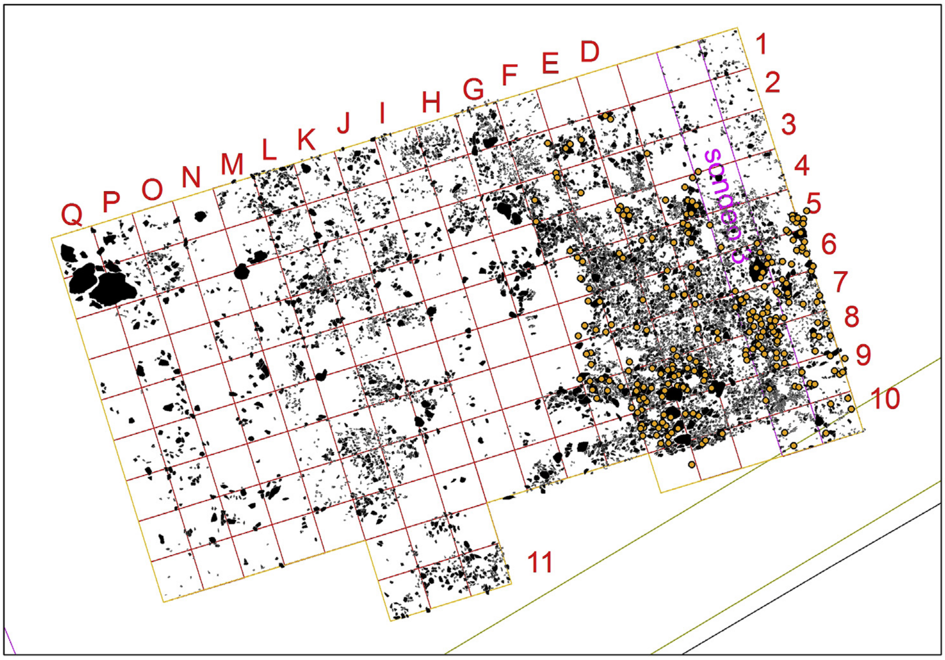

Fig. 5. Nodules distribution.

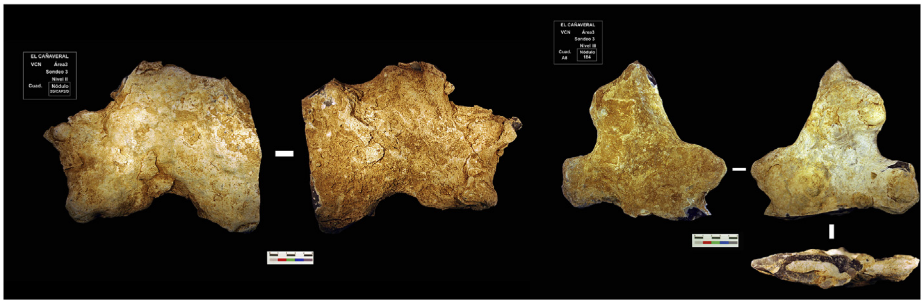

Fig. 6. Example of nodules.

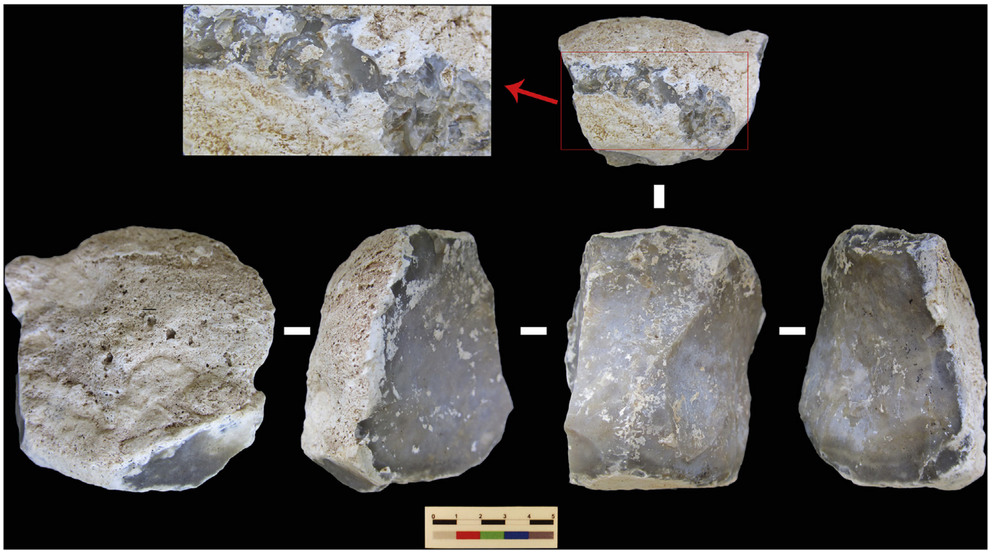

Fig. 7. Recycled nodule as a hammerstone.

the same time. More than the half of cores was made of flakes (59.4%), while fragments are 30.7% of supports and nodules are 9.9% (Table 5).

Table 5
Types of cores supports.

	Flakes	Fragments	Nodules	Total
Levallois	29	1	4	**34**
Discoid	10		2	**12**
Polyhedron		9	3	**12**
Expeditious	32	29	4	**65**
"Irregular"	49	23	7	**79**
Total	**120**	**62**	**20**	**202**

Measurements were documented. The graph below shows how Levallois and Discoid cores are concentrated, where their growth is exponential. Polyhedron cores are different. If we take into account their normal supports (Fragments), and their technology, their shape tends to be more cubic, and their measurements have a bigger range. Finally, expeditious and "irregular" ones do not have a regular shape, since they are bigger expeditious cores (Fig. 8).

Having analyzed all cores, we compared our measurements of last removals with those of tools. Our aim was to check if the objective of the knapping processes was to obtain supports to make tools or just to exploit cores to obtain flakes. As the graph shows, there is no direct relationship between the last removals and tools measurements. Retouched tools are made, most of them of flakes, measuring between 4 and 8 cm in length and 2 and 6 cm in width, while last removals are concentrated with 1–4 cm in length and 1–4 cm in width. Tools are made on supports from plain exploitation phases, predetermined flakes, while cores are still exploited until they are exhausted in some cases (Fig. 9).

Different knapping technologies were documented, mostly thanks to refits. This helped us to obtain basic information about knapping processes, gestures and finalities.

Levallois, Discoid, and polyhedron cores were all documented.

The first of these is unipolar sequences, where a unipolar parallel sequence was removed from the same striking platform. These are documented by flake refits, and in some cases with core remains (Fig. 10).

In this case it is possible to see a unipolar, almost convergent, sequence where pieces were refitted thanks to patina rupture. Two phases are documented: the first is the initial removal of a backed flake (1) to create an angular configuration. The second phase is unipolar convergent, where each flake striking platform is flat, except for a backed flake (4) which is faceted, which configures volume and convexity.

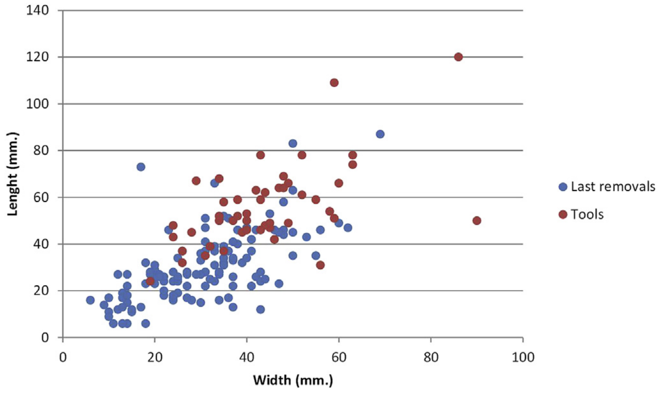

Fig. 9. Comparison of cores last removals and tools measurements.

On this second refit complex there is a unipolar and orthogonal extraction system to obtain a Levallois point. In the first phase, there is an orthogonal series where each flake has a flat striking platform. In the second stage we see the preparation of a Levallois point by the convergent method, or the preparation of a lateral & divergent medial/distal ridge (Usik et al., 2013). This is also called unipolar and orthogonal preparation removals (Crassard and Thiébaut, 2011). The third phase was the extraction of a Levallois point with a dihedral striking platform (Fig. 11).

In the refit below a convergent unipolar series is documented where two Levallois points are removed (number 3 and 5). Both points have faceted striking platforms, while the rest have dihedral ones. Between extractions 1 and 3 a flake removal remains (2) at the left side of the first Levallois points, and is convergent with the first removal. In this case, this Levallois point has a proximal divergent ridge preparation, as does the second point. These are also called as convergent unipolar preparation removals (Crassard and Thiébaut, 2011) (Fig. 12).

The second method documented is that of bipolar sequences, where parallel series of flakes are removed from an opposite

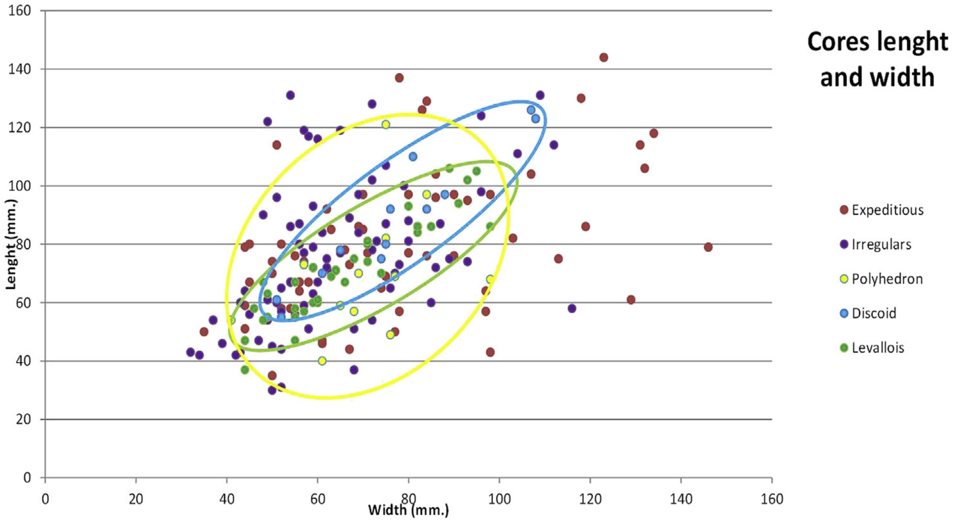

Fig. 8. Comparison of cores measurements.

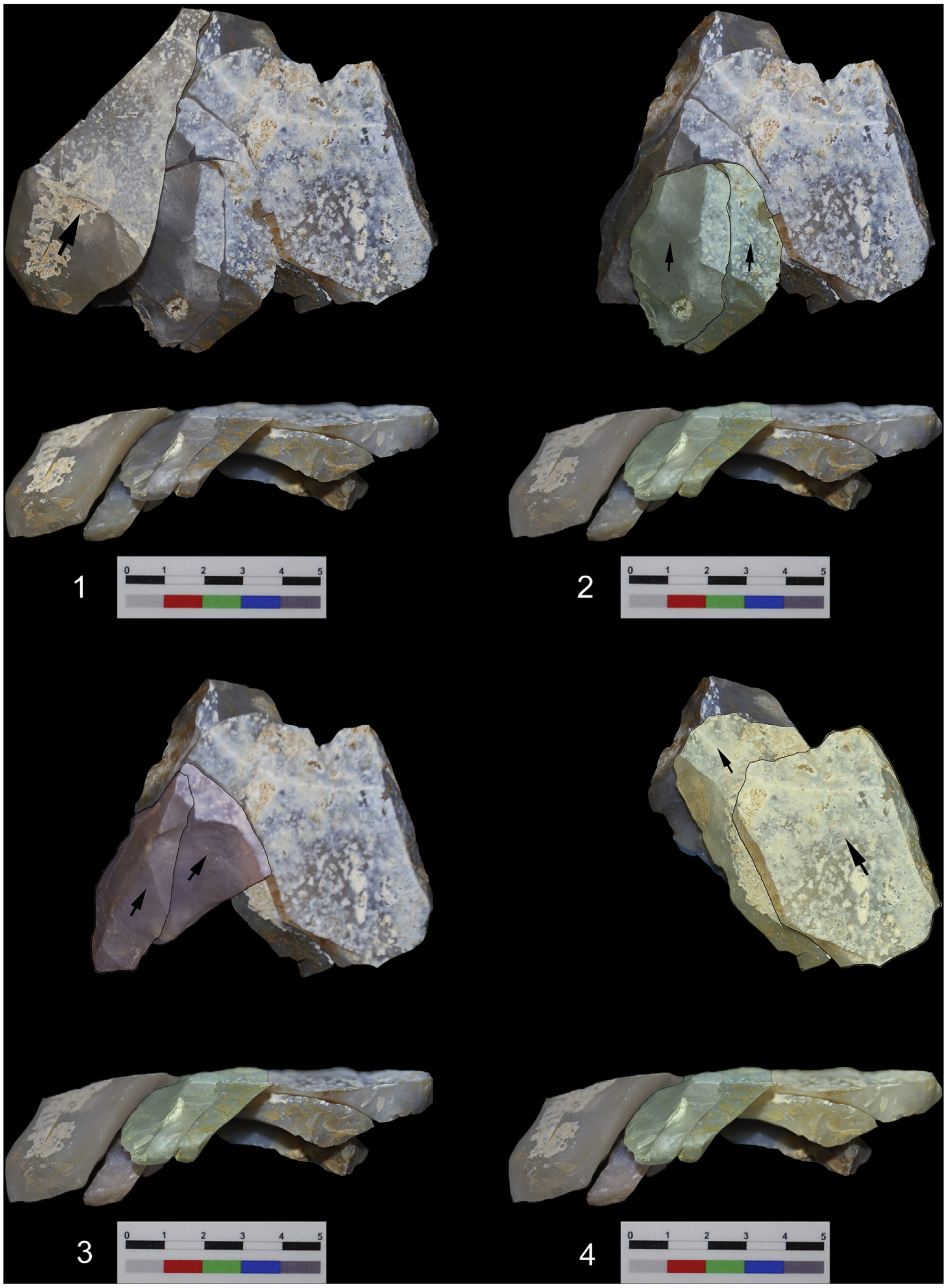

Fig. 10. Example of a unipolar sequence.

striking platform. In the figure below, there is a unipolar convergent sequence to extract a Levallois point. One of these two artifacts is a backed flake, but its striking platform is broken, so we have no information about the type. After the point extraction (2), there is a bipolar sequence based on 3 backed flakes which are removed to fix the core convexity. Two of these flakes have a dihedral striking platform, while the rest have a flat platform, even the Levallois point. The existence of bipolar sequences could finally be the result of new production sequences (that obviously include the creation of distal convexities) (Fig. 13).

In this refit, as seen in the figure below, the core support is a big cortical flake that is broken. This core is exploited by parallel series: In the first stage, the natural edge was used to extract a pair of blades by lateral backed flakes in order to prepare a particular angular relationship between planes and/or create convexity on the sides (1). In the second stage, a pair of parallel flakes was removed from the primary reduction surface (2). One of the flakes is a backed one, to fix the core convexity. In the 3rd and 4th series, the striking platform is prepared by a bipolar series, and number 4 by parallel backed flakes using a natural edge.

In the third stage different actions take place. The first one (5) is preparing distal convexity by parallel series. The next step was faceting a striking platform, and the last (7) was the removal of the final flake. But there is still a point on the core. It has a triangular

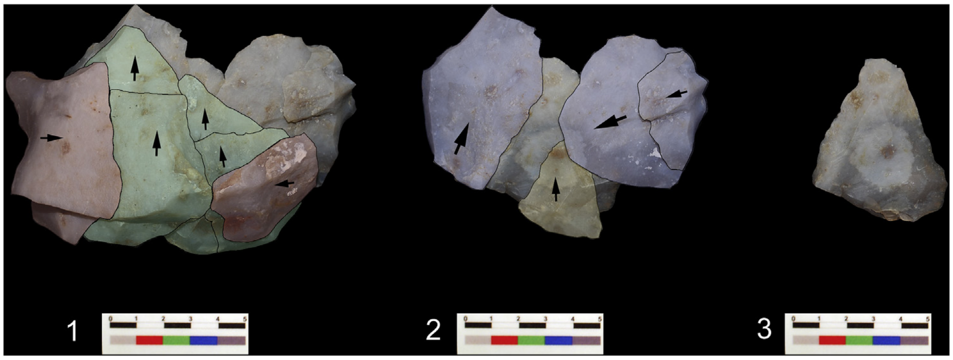

Fig. 11. Unipolar and orthogonal system to obtain a point.

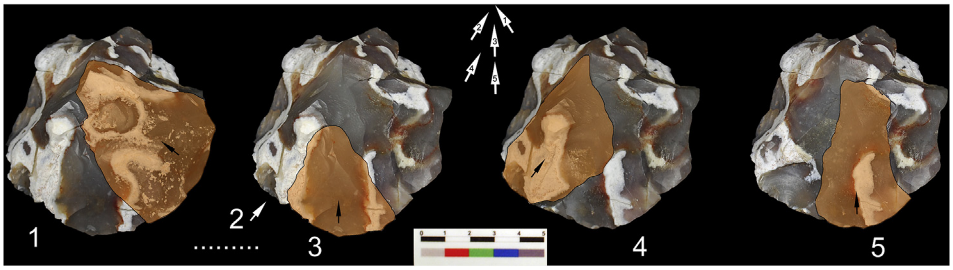

Fig. 12. Convergent unipolar series to obtain two points.

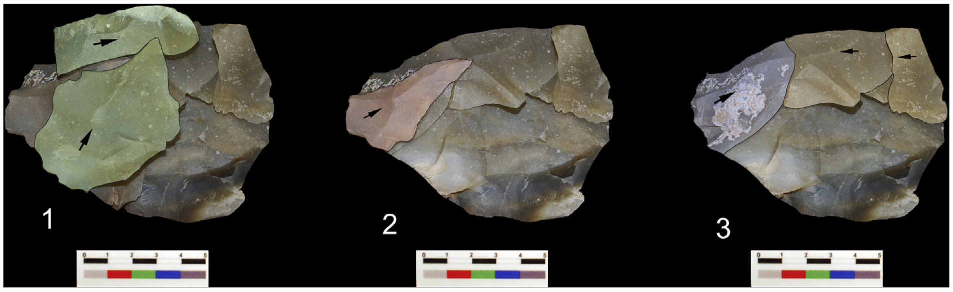

Fig. 13. Example of bipolar and convergent sequence to obtain points.

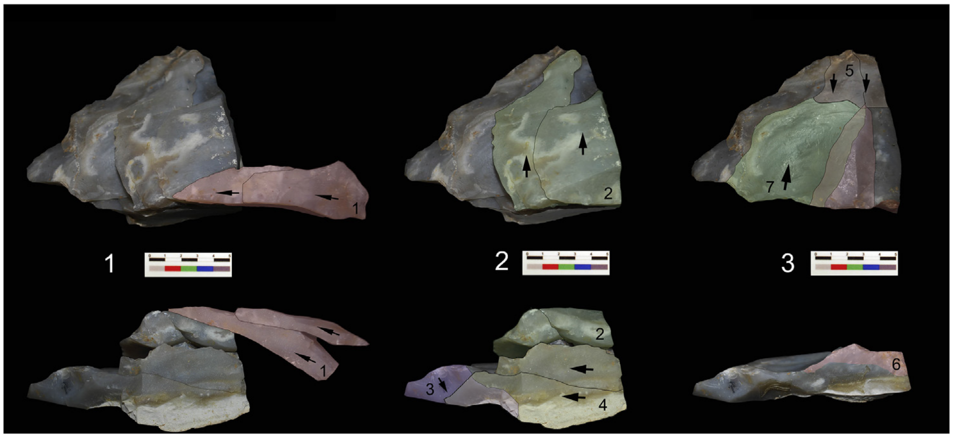

Fig. 14. Example of an exploitation sequence.

shape and a delta which is prepared to be removed by convergent unipolar preparation removals with few removals that accentuate the distal convexity (Crassard and Thiébaut, 2011) (Fig. 14).

The third technique is the centripetal method, where all removals have a centripetal or cordal direction. These cores are exploited to the extreme of their possibilities. The last exploitation phase has no reconditioning surface; finally, the last extraction is more invasive than the others (Fig. 15).

In this case there is a centripetal Levallois core, with asymmetric exploitation.

The first phase is the preparation of a striking platform with a convergent unipolar series of flakes. This convergent method creates dihedral striking platforms on the other surface. The opposite side has another unipolar series, which also involves preparing striking platforms.

In the second phase, the core is used to exploit the primary reduction surface. A unipolar series was removed, with false dihedral striking platforms. This flake series has flat striking platforms but is morphological dihedral, and this caused false backed flakes.

In the third phase there is a cordal series of removals. Finally, in the last stage a great surface of striking platforms was faceted, and three flakes removed (2 refits). The first two of these flakes were hinge flakes and the third was an attempt to make a transversal reparation of the knapping surface. This did not work, however, and they abandoned the exploitation.

According to the preferential method not a single refit has been found with this method. In order to study these cores we have carried out a diacritic analysis. In such cases the core is fully prepared for the removal of one flake. The perimeter is prepared by fixing lateral–distal convexities and preferential flakes are used so as to have faceted or dihedral striking platforms.

In the figure below, the first support seems to be a small flint nodule. In the first core there are some “ancient” removals,

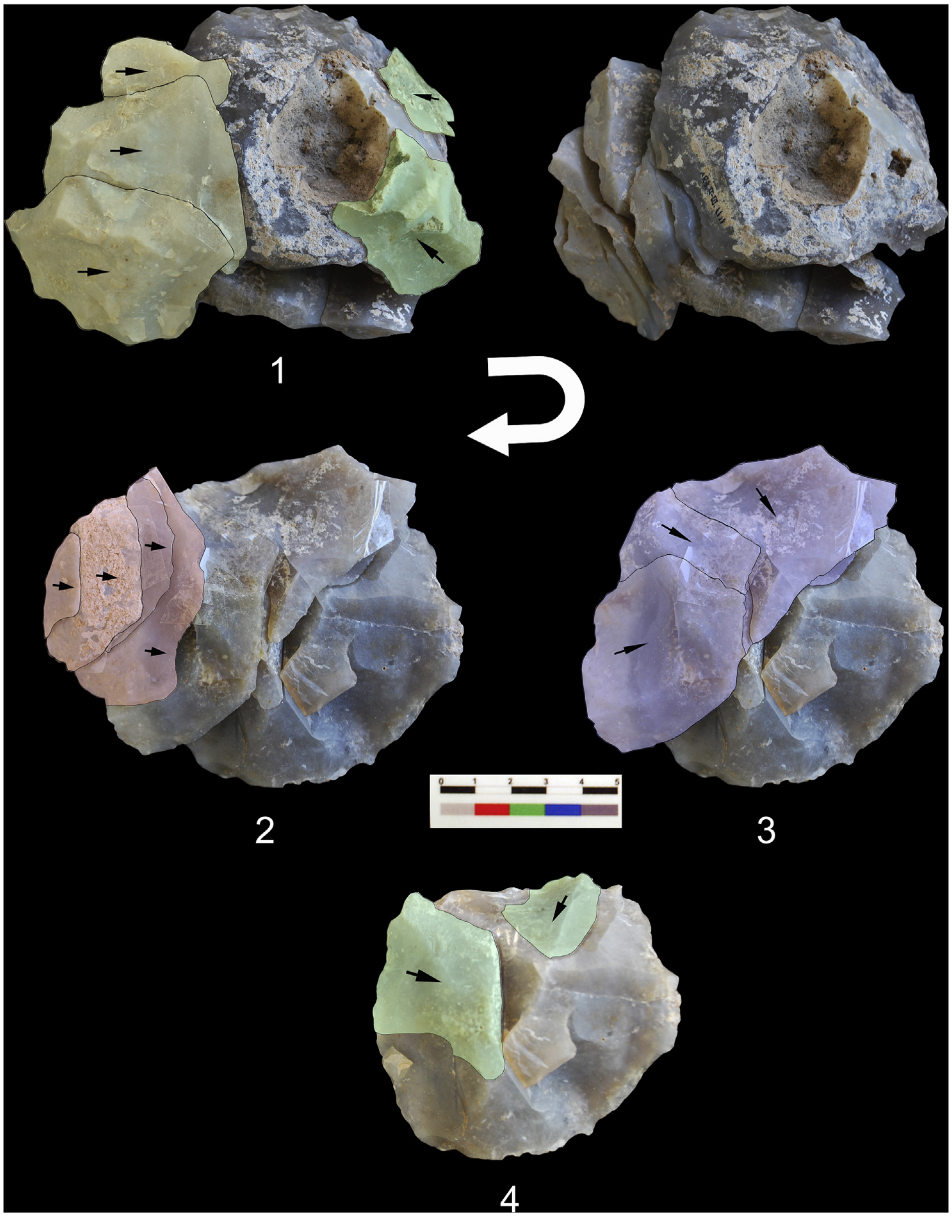

Fig. 15. Levallois Centripetal refit.

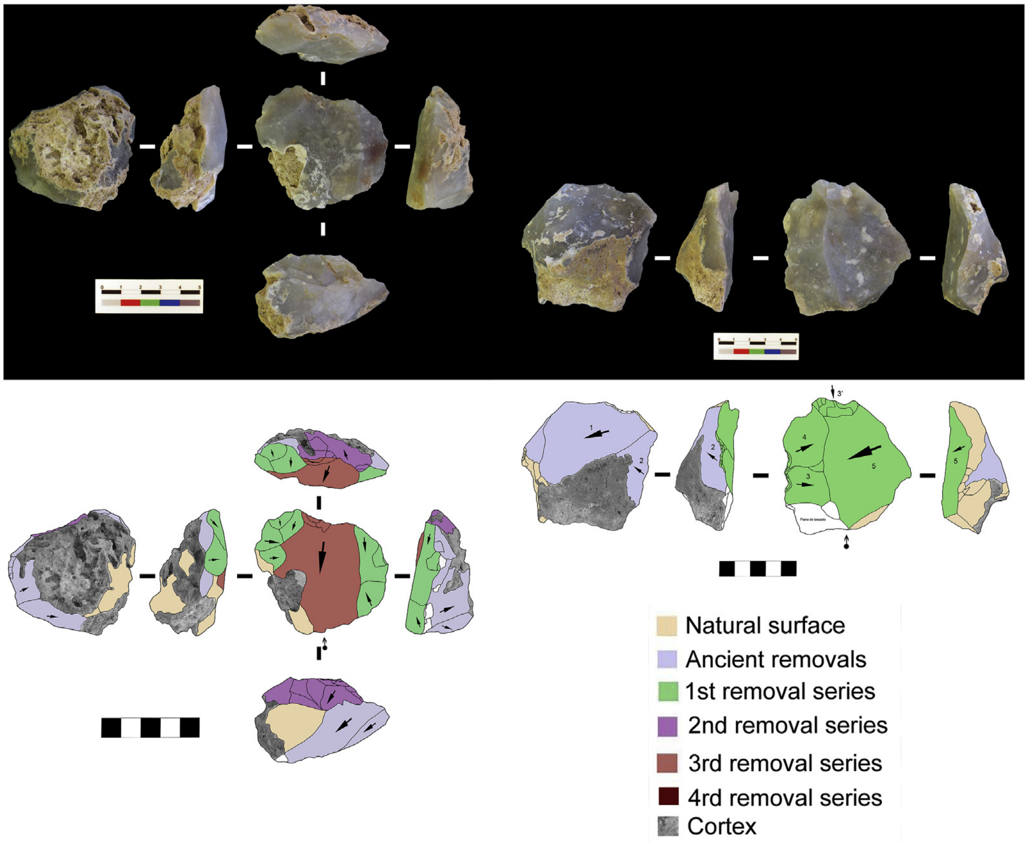

Fig. 16. Preferential method analysis.

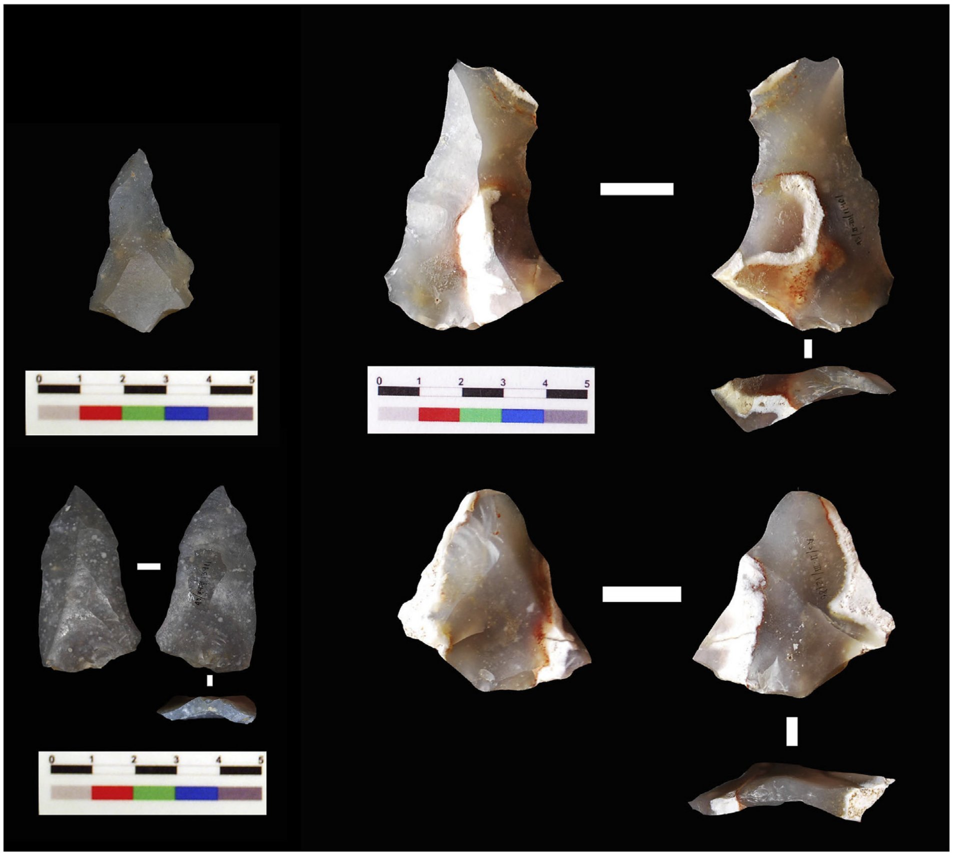

Fig. 17. Final products, Points.

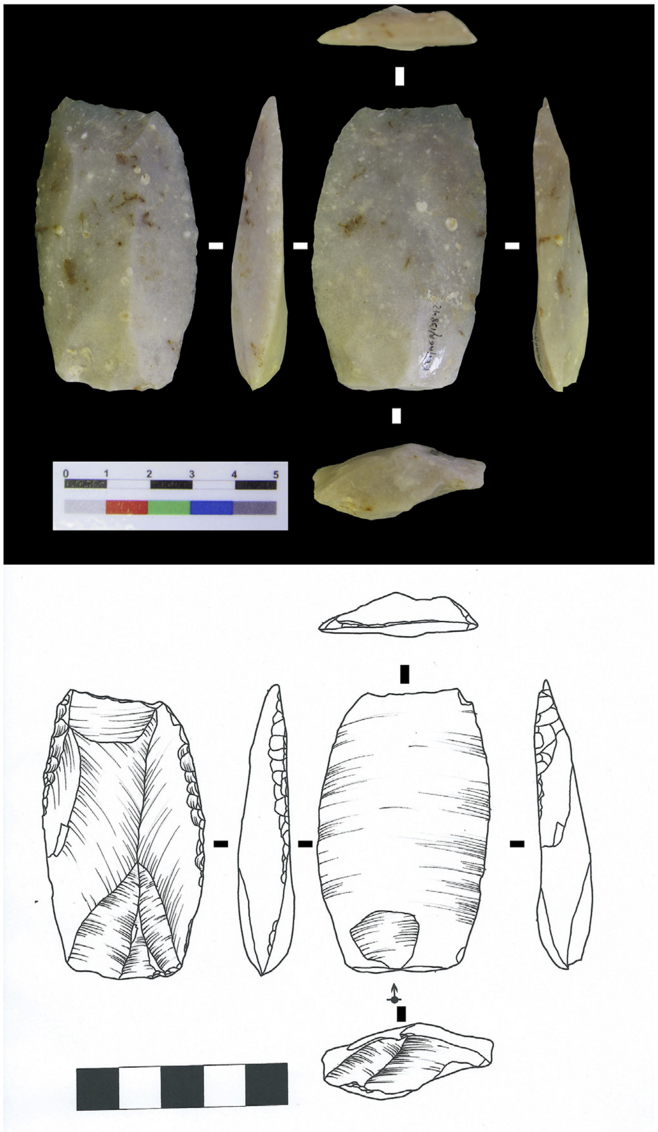

Fig. 18. Scraper.

preparing striking platforms; the next step was to prepare core convexities by lateral removals from the primary exploitation surface. After that, the striking platform for the preferential flake was prepared and finally this last flake was removed. The problem was the appearance of cortex on the exploitation surface (Fig. 16).

The second core is a cortical flake where two removals prepared the striking platform. The next step was to prepare lateral convexities by a parallel series, and the preferential flake was removed using the bipolar method.

5.3. *Final products*

The aim was to procure raw material and in some cases obtain some final products as points or preferential flakes. Certain tools including scrapers or notches were also documented (Fig. 17).

Fig. 17 shows examples of points documented in Area 3. The first of these is a Levallois point with dihedral striking platform with “Chapeau de Gendarme” morphology and distal convergent ridge preparation (Usik et al., 2013), which is also called opposed unipolar reparation removals (Crassard and Thiébaut, 2011). The point below has a flat striking platform and almost straight convex platform morphology. Distal preparation seems to be proximal-convergent or convergent unipolar (Crassard and Thiébaut, 2011). Both points on the right side come from the same core. They have a faceted striking platform, with convex morphology and proximal-convergent distal ridge preparation. This shows that the main procedure used to create points was the unipolar convergent method.

Some tools were also documented, and at least in one case it was possible to find a notch refitted with the core, so that means that in some cases some tools were produced on the site. As we can see, there is a scraper and a couple of notches. The former is a double scraper, whose support is a flake with a dihedral striking platform. The retouch is situated over the dorsal face, and there are some scratches on the distal part of the tool (Figs. 18 and 19).

The latter are two notches over a flake, one of them refitted with the core. This retouch was made over the dorsal face of the flake.

5.4. *Hammerstones*

There were 18 hammerstones documented in Area 3. Most of these are made on quartzite pebbles (n = 10), while another 7

Fig. 19. Detail of a notch and a refitted notch with a core.

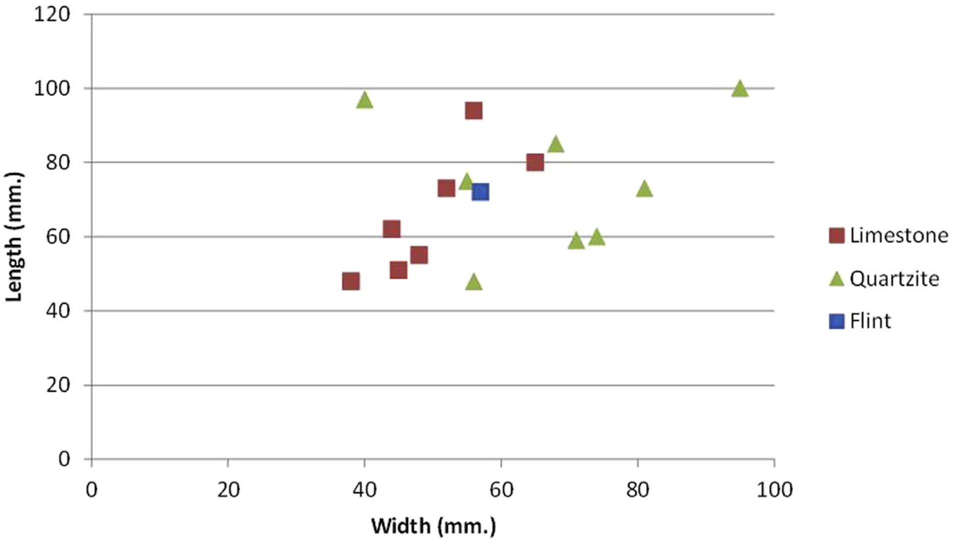

Fig. 20. Hammerstones measurements.

hammerstones were also documented in limestone and 1 in a flint nodule (Table 6) (Fig. 20).

Table 6
Different hammerstones raw material.

Hammerstones	
Quartzite	10
Limestone	7
Flint	1
Total	**18**

All hammerstones were measured and their weight was noted. As we can see in the graph, limestone hammerstones are the most regular, measuring between 4 and 7 cm wide and 5 and 9 cm long. Quartzite ones are the largest, and do not share a homogeneous morphology, measuring between 4 and 10 cm wide and 5 and 10 cm long (Fig. 21).

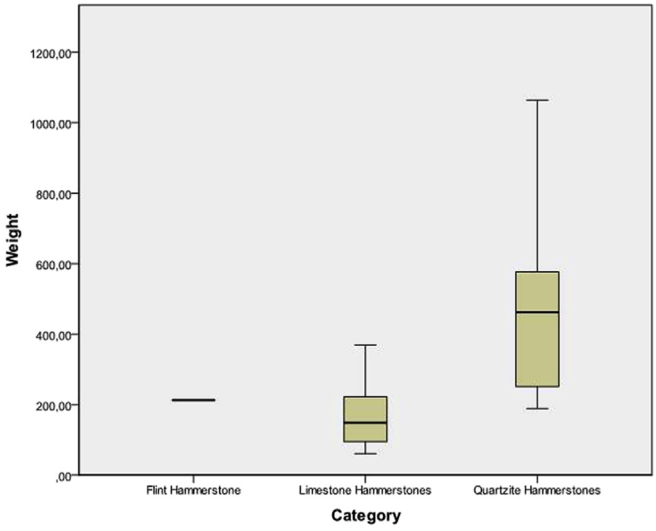

Fig. 21. Comparison of hammerstones weight.

According to their weight, flint hammerstones were the lightest, weighing almost 200 g; limestone hammerstones have a mean range of between 100 and 200 g, with a maximum weight of 400 g. Finally, quartzite hammerstones are the largest and also the heaviest: the mean weight is between 200 and almost 600 g, with the heaviest weighing over 1 kg (Fig. 22).

5.5. Recycling activities

During the technological analysis, some recycling activities were also documented. Nowadays lithic recycling is a controversial concept, because, although specialized conferences have taken place on this objective, no clear definition exists.

The important concepts are:

- There should be a functional change between the first use and the second use of the artifact (Vaquero, 2011; Vaquero et al., 2015) Remodeling is not necessary.
- There should be a short-term lapse between two functions (Baker, 2007).
- The recycling activity should be done by the same first user or by a user from the same group who knows the original function of the artifact.

With regards to cores, 11 flint cores were recycled as hammerstones after their exploitation. There were 16 nodules also found with concentrations of percussion scars, which shows that they may have been used as hammerstones or anvils, because in some cases they are too large to have been used as a hammerstone. Finally, there are some hammerstone fragments that have been reused as hammerstones (n = 4) (Table 7).

Table 7
Different recycled elements.

Recycling	N°
Nodules	16
Cores	11
Fragments	4
Total	**31**

Fig. 22. Example of hammerstones.

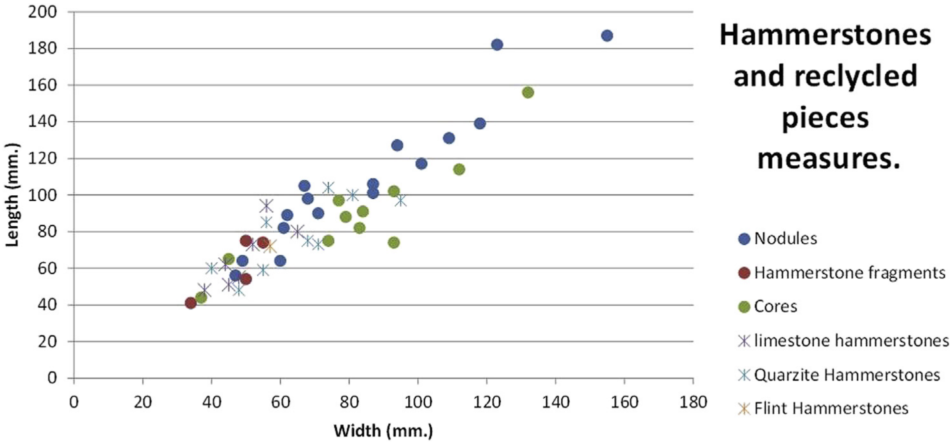

Fig. 23. Measurements comparison of hammerstones and recycled pieces.

All recycled pieces were measured and weighed. On the graph below, there is a size comparison between real hammerstones and recycled ones (cores, nodules and fragments used as hammerstones). The original ones are very concentrated, measuring between 4 and 10 cm in width and length. Most of recycled cores are within these measurements, except for 2 of them, while nodules are bigger. There is an exponential size increase, with some between 18 and 20 cm in length and almost 16 cm in width. These pieces cannot be used as hammerstones, but have percussion concentrations on their surface, so they could have been used as anvils instead of hammerstones (Fig. 23).

Weight was also compared. As we can see below, recycled cores and original hammerstones are in the same weight range. The mean weight is around 500 g, with the heaviest 1 kg. Hammerstone fragments are lighter and smaller, so their use could be similar to that of retouchers. Finally, recycled nodules are the heaviest, with their average weight more or less in the same range as cores and hammerstones, but with greater differences in weight. The heaviest is almost 1.5 kg (Fig. 24).

In the figure below, there are some examples of a recycled nodule and two recycled cores. On the left side there is a nodule with a dense concentration of percussion marks situated on one of the edges.

On the right side, the first core has 3 percussion concentrations. All are situated on edges of the striking preparation surface of the core. Finally, the lowest core also has 2 concentrations of percussion scars. These are situated on the perimeter edge of the core, with a convex angle, which is suitable for knapping (Fig. 25).

Some hammerstone flakes and fragments that were retouched as tools were also documented. These could be interpreted as

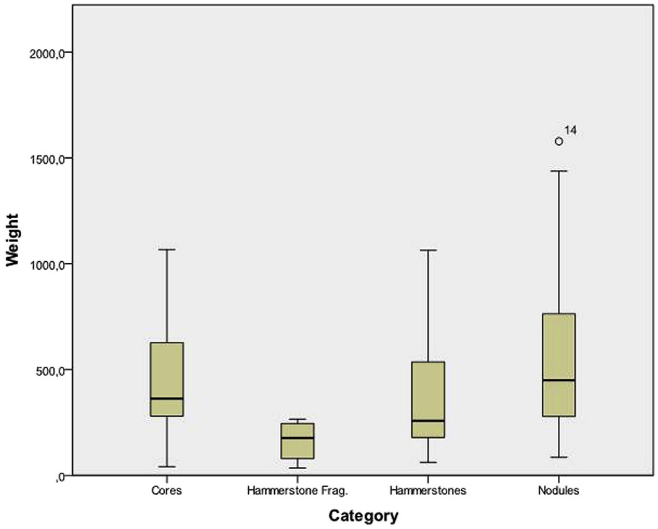

Fig. 24. Weight comparison between hammerstones and recycled pieces.

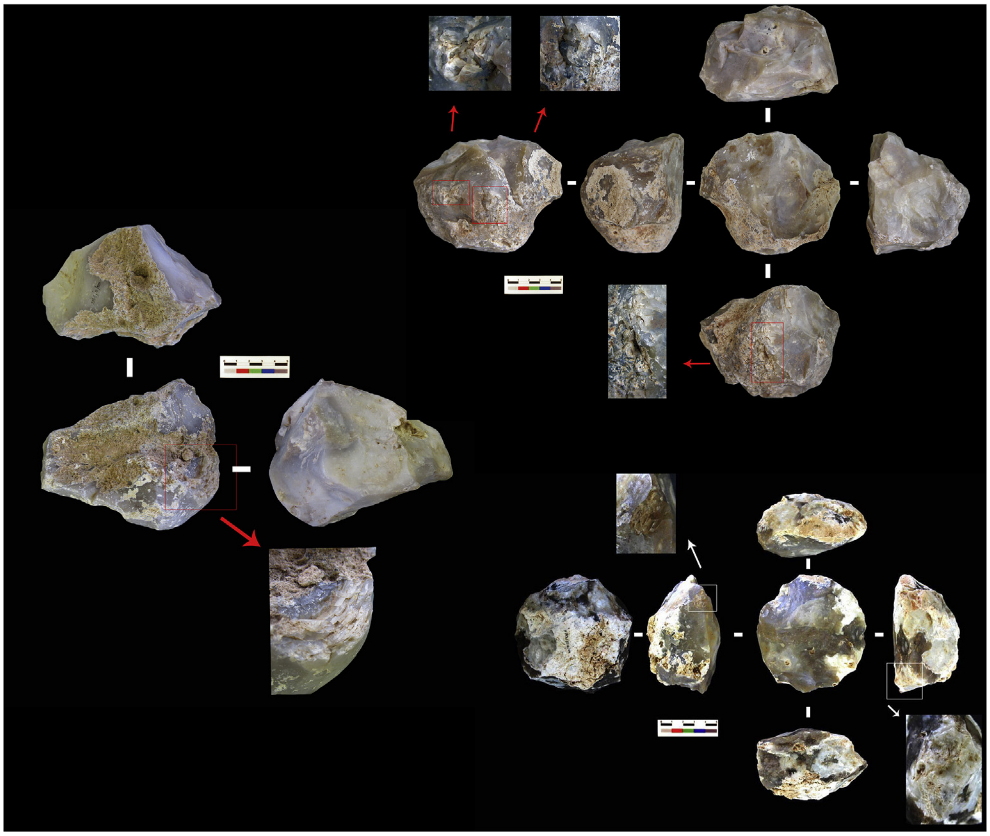

Fig. 25. Example of cores recycled as hammerstones.

examples of recycling or of secondary raw material supply. The first could be argued by the fact that hammerstone fragments were used to make some tools, and the second because quartzite flakes were used as supports to make new tools. There is other question, however, to tackle here: Why are tools being made out of quartzite if there is a considerable amount of flint available in the surrounding areas?

In the figure below, the left piece is a big quartzite flake retouched on its perimeter, with use marks. The second piece is a quartzite scraper, made from a flake. It has been retouched on the left lateral side and on its distal part (Fig. 26).

Thanks to all this information obtained about knapping processes, technologies used and different recycling processes it was possible to define the operative chain schemes documented in Area 3, from the first phases of flint quarrying and testing quality, until the last phases of tool exploitation, recycling activities and abandonment (Fig. 27).

6. Discussion

This paper shows the exploitation system documented on Area 3. We were able to identify all phases of the *operative chain*, from the raw material catchment to the use and abandoning of tools. These latter actions are interesting, because this site was a quarrying area, where the main activity was supposed to be flint supply. As a result, we would expect to find evidence of the first phases of testing nodules and first moments of exploitation. However, some examples of tool production are found and even some use marks on the edges of the tools, which are currently being investigated.

A hearth was also discovered in Area 3 (Ortiz Nieto-Márquez, 2013; Ortiz Nieto-Márquez and Baena Preysler, 2015). Knapping remains and refits were found around the fire place. There were also thermal refits inside the hearth cuvette. It is important to stress the fact that the fire place appeared in a lithic workshop, where we would expect short-term occupations, but this fire shows that at least one of these multiple occupations was a middle/long-term one.

This hearth marks the presence of fireplaces in middle Paleolithic open air sites and not only at caves or shelters such as Abric Romaní (Chacón et al., 2007; Courty et al., 2012; Vallverdú et al., 2012), El Salt (Dorta Pérez et al., 2010; Mallol et al., 2013), Abric el Pastor (Vidal-Matutano et al., 2015), El Esquilleu (Yravedra and Uzquiano, 2013), Abrigo de la Quebrada (Eixea Vilanova et al., 2011), Roca dels Bous (De la Torre et al., 2004) and Vilas Ruivas (Portugal) (Bicho, 2004; Cardoso, 2006; Roebroeks and Villa, 2011) in the Iberian Peninsula among others.

Its presence in Area 3 could be interpreted as the result of a short-duration occupation, where the main activity was the raw material catchment and knapping processes, and where hearths were not limited to settlement sites. It could have created social cohesion and provide light and heat (Guan et al., 2011; Blasco et al., 2015).

Abiotic resources (flint) were exploited at this site. This activity could be defined as a social organized complex of activities of an extractive character whose aim was to obtain the resources of a territory, by making use of superficial or underground exploitation systems, made by human prehistoric communities in order to obtain some raw material to manufacture, use and/or exchange it (Mangado, 2006).

In the surroundings of Area 3-El Cañaveral, several open-air sites have been documented whose main activity was raw material supply (flint): Canteras de Vallecas and Cerro Almodovar (de

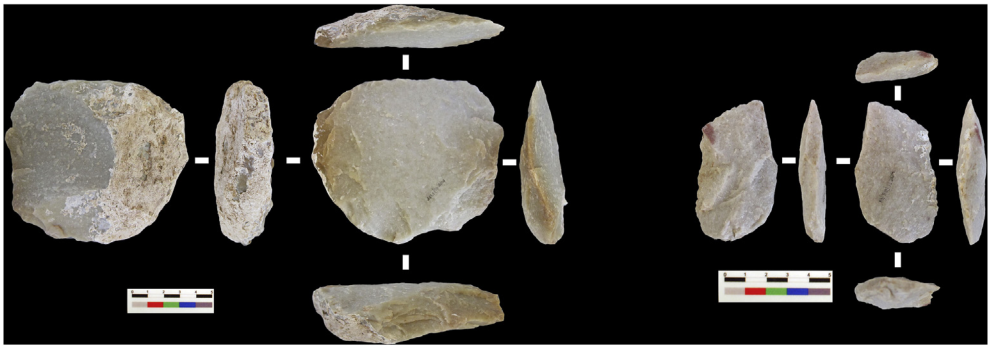

Fig. 26. Example of retouched quartzite flakes.

Barradas, 1919, 1926; Triguero, 1956a, 1956b), La Gavia I (Rus, 1989; Manzano et al., 2005), Perales del Río (Cobo Rayán et al., 1983; Baena Preysler, 1992, 1994), Los Estragales (Pérez González et al., 2008)y Soto e Hijos (Baena Preysler, 1994). Casa Montero is a Neolithic mine at around 4 km from Area 3 however there are some Pleistocene deposits with Mousterian industry and combustion structures that could be related to middle Paleolithic flint exploitation (Bustillo and Pérez-Jiménez, 2005; Bárez and Pérez-González, 2007; Criado et al., 2011; Bustillo et al., 2012; Castañeda, 2014).

However, as we have shown in this paper, it is not only extractives activities that were carried out at this site. There were also some testing nodules to check flint quality; there were some knapping processes to reduce nodule volumes in *misse en forme* activities, and also some plain exploitation phases to produce tools.

Regarding nodules, we should stress the fact that concentrations of percussion marks were documented on the surfaces of some flint nodules. This could be related to the nodule configuration processes. According to Xavier Terradas, nodule configuration near raw material quarrying sites is considered a means of saving energy by casting aside unnecessary volume and weight, in other words, to obtain optimum efficiency in transporting raw material and its exploitation (Terradas, 2000, 2001). The concentrations of percussion marks could also be caused by nodule dividing processes to evaluate the quality of raw material, however.

Extremely simple transport technologies were also documented, such as a selection of nodules whose morphology is close

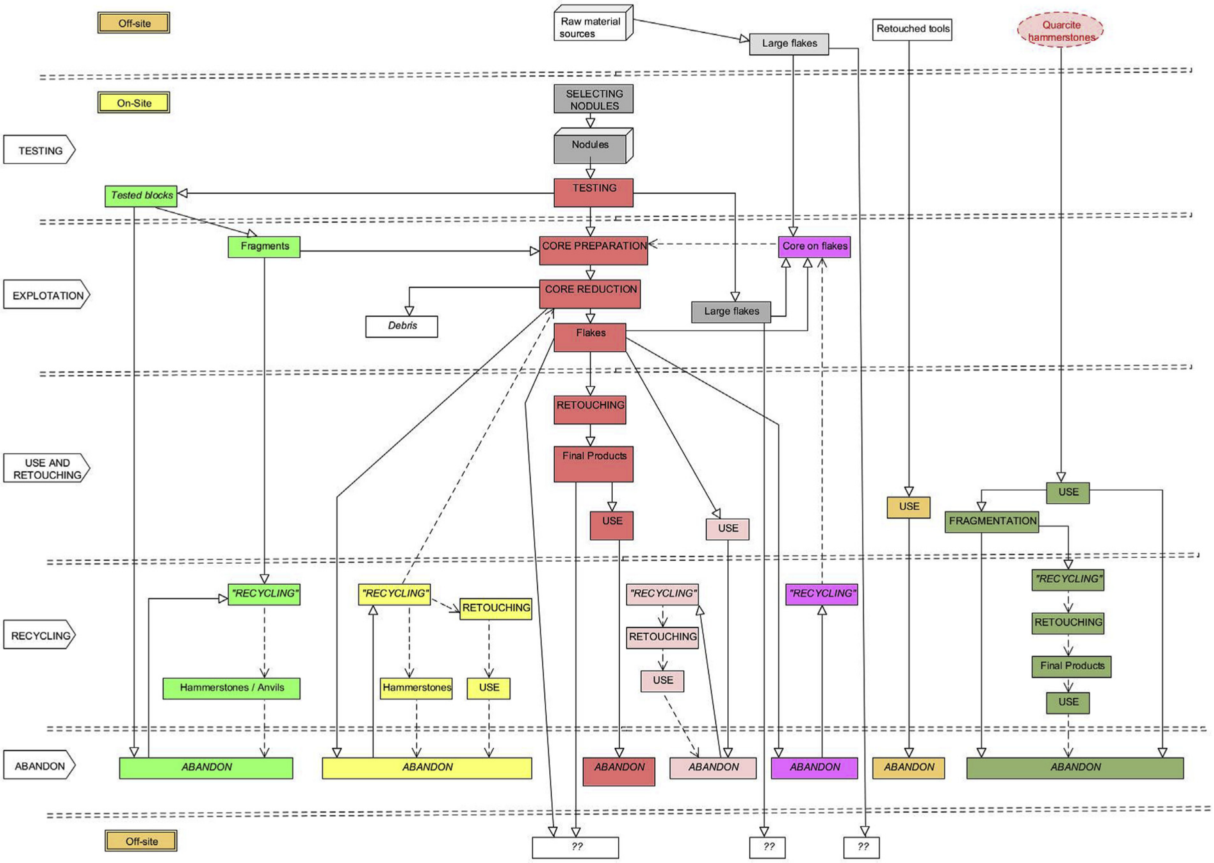

Fig. 27. Operative chains scheme of Area 3, El Cañaveral.

to next volumetric abstraction. In this way, it seems that the population was looking for certain morphologies, maybe for core recycling, such as hammerstones. The majority of nodules measure between 5 and 15 cm wide and 5 and 20 cm long. This is a suitable size to start the knapping processes, because it is not very heavy and can be transported.

However, when specific morphologies cannot be sourced, changes are made through fragmentation or knapping. Studies had established 3 ways of changing morphology: 1) striking a nodule head on to break it, 2) Striking a nodule that works as passive hammerstone, and, finally 3) they throw a nodule over another (Terradas, 2001). This could explain the crushed concentrations documented on several flint nodules, since they may have been used as active or passive hammerstones to check flint quality and to modify nodule morphologies for the future transportation of knapping processes.

This site was not only a raw material quarrying site; it was also a workshop where different transformation processes of raw material in order to obtain certain products have been documented. A workshop can be defined as archaeological remains that show certain human behavior connected with the exploitation of natural resources the use of techniques to supply their economic and social necessities (Ramos Muñoz et al., 1988; Baena Preysler, 1992; Morlote and Barquín, 1992; Vallespí Pérez, 1968, 1992; Fernández and Marrero, 1998; Carrión Santafé and Baena Preysler, 1999; Conde Ruiz et al., 2000; Mangado, 2006). In Area 3 remains of the supply of flint nodules have been found, as have vestiges of their later exploitation, justified by the discovery of different *operative chains*.

According to the first phases of exploitation (Geneste, 1985), certain nodules and cortical/non cortical flakes were used as supports. With this process, energy and time was saved because most Levallois and Discoid cores were made from flakes (Tixier and Turq, 1999; Bernard-Guelle and Porraz, 2001; Zieba et al., 2008). Supports suitable for Levallois and Discoid knapping reductions were sought after, with a particular morphology and convexities that already exist on flake supports, so there was no need to adapt another piece for their needs.

The fact that flakes were used as supports for exploiting cores could be interpreted in different ways. Firstly, it could be seen as secondary raw material catchment, when these flakes were taken from the raw material surface. Secondly, it may be seen as an example of recycling or ramification processes, when they fashioned the flake from reused lithic (in some cases there is double patina that shows two different moments), or if the flake was taken from other knapping processes (Bourguignon et al., 2004; Amick, 2007). But, were these flakes were made on purpose? Were knappers making specific supports for Levallois and Discoid methods? This could be an evidence of previsioning actions.

With regards to technology, there are differences between striking platforms and the preparation of preferential or non-preferential pieces. It has been documented that only some backed and some preferential flakes have faceted striking platforms. The backed flakes are very important for keeping core convexities and volumes, so if the extraction of this piece fails, the whole core is discarded. This is why most backed flakes undergo a considerable striking platform preparation, as faceted or dihedral ones do. On the other hand, to save time, flat or dihedral platforms were used to remove the majority of flakes. Only in some specific cases, such as with Levallois points or preferential flakes, would the platform be prepared a little, but this wasn't always the case.

The production of Levallois points have been described according to two modalities of preparation (Bordes, 1980): Firstly, preparation by unipolar convergent removals flaked from the striking platform of the future point, or a unipolar divergent preparation by removals made from a striking platform opposite to that of the future point. In addition, there were two main groups: the so-called three hit points (Classical points), which are distinguished from the constructed point in which different schemes coexist depending on the direction of the preparation removals (Boëda et al., 1998).

In this paper, our study has been established based on the direction of the preparation removals seen on the *débitage* surface of the core and dorsal face of the point (Crassard and Thiébaut, 2011; Hérisson, 2012; Goval et al., in press), and of course based on refitting remains. Most of the documented points in Area 3 have a classical preparation, convergent or opposed unipolar preparation removals, and in some cases some lateral or distal retouches, with faceted, dihedral and some flat platforms.

In terms of recycling activities (Amick, 2007, 2014, 2015; Baker, 2007; Claud et al., 2010; Baena Preysler et al., 2015; Cuartero et al., 2015; Romagnoli, 2015; Vaquero et al., 2015), the site is full of remains, but what should be stressed is the context of these actions: Area 3 is a big raw material supply with tons of flint on the surface. Why did they need to recycle or reuse the materials?

There are some used or “recycled” nodules, which were used as anvils or hammerstones to open up other nodules. If we associated it with the lack of big quartzite hammerstones, it could be possible to justify this use or application of nodules as an economic necessity of big proper hammerstones.

The use of flakes as cores could be consider “recycling” (Agam et al., 2015; Barsky et al., 2015; Cuartero et al., 2015; Parush et al., 2015; Vaquero et al., 2015), but under our point of view this action could respond to a secondary catchment processes or “application”, focused on time and effort economy (Baena Preysler et al., 2015).

However, some cores were properly recycled as hammerstones. As we can see, these activities are by no means uncommon. There are some sites with similar samples, such as *Cantalouette 1* (Dordogne) and *Combe Brune 2* (Dordogne), excavated by M. Brenet (Brenet et al., 2008a, 2008b; Frouin et al., 2014); *Saint-Cesaire* (Charente-Maritime) excavated by F. Lévêque (Thiébaut et al., 2009; Crassard and Thiébaut, 2011); *Chez-Pinaud* (Charente-Maritime) by J. Airvaux and J. Jaubert (Jaubert et al., 2008); *Les Roches-de-Villeneuve* (Vienne) by C. Beauval and E. Morin (Beauval et al., 2007); *Abric Romaní* (Spain) by E. Carbonell (Vaquero et al., 2015) amongst others. Cores and handaxes were found showing traces of percussion and crushing.

Some percussion traces were analyzed in experiments and compared with archaeological pieces (Thiébaut et al., 2010). It was shown that the type of stigmata (crushed concentrations) depends on the morphology of the active zone and, thanks to experimentation and comparisons, it was recognized that the mass distribution of handaxes and cores used as hammerstones is similar to that of the more classic retouchers and hammerstones on blocks, so recycling pieces were probably selected on account of their weight.

As we demonstrated before, we discovered similar patterns. We compared recycled cores used as hammerstones with original hammerstones and found that most of them have the same size and weight. In this way, perhaps specific hammerstones were not being made, but were selected because of their size and weight, in an attempt to find same qualities as “real” ones? This could respond to some ramification processes (Bourguignon et al., 2004, 2008). Nowadays, from our point of view and awaiting more in-depth studies, these activities could respond to economic necessity of proper quartzite hammerstones.

Other activities were also documented, like retouching quartzite supports to make tools. Some quartzite flakes were also found with retouched edges and use marks. This could be interpreted as secondary raw material supply, or an example of recycling processes.

But the main question to answer is: Why? Why were they using quartzite to make tools at a site where flint was in abundance? It may be that they needed certain quartzite qualities over flint ones for their tools? Retouched edges in quartzite and flint are not the same; the latter is much sharper than the former. Or maybe they did not need to obtain such good results, so they just used these fragments or hammerstone flakes to finish their task.

So, Area 3 is not only a standard raw material quarrying site, because there are almost complete operative chains, in some cases showing last tool production phases and the use of them. The presence of a fire place on the same level (level II) with knapping remains and some tools in the surrounding area could complete our vision of the site functionality.

7. Conclusion

Area 3 is an open-air raw material quarrying site occupied during middle Paleolithic periods. Almost all phases of the *operative chain* were documented there, from raw material procurement and testing quality to tool production and use. This is one element that makes Area 3 stand out from standard Paleolithic workshops. Another important fact is the presence of a fire place that shows a “mid/long-term occupation”, instead of “short-term occupation”, as in the majority of workshops. Different *operative chain*s were analyzed according to nodules and cores exploitation, and recycling processes occurred in an abundance context.

Levallois points were one of the objectives of the exploitation, with some preferential flakes used to make tools such as scrapers, denticulates and notches. The presence of the final products in a workshop is interesting, even more so when they are connected with works around a fire place. Area 3 is a great archeological site that allows us to understand certain Neanderthal behavior, in relation with the lithic supply and exploitation systems, as well as some consumption activities.

Acknowledgments

This research has been conducted as part of the research projects “Algo más que bifaces: hacia la definición técnica y tecnológica de los conjuntos líticos del pleistoceno de la región de Madrid”, Reference: HAR2010-20151, and: “¿Cómo, quién y dónde?: Variabilidad de comportamientos en la captación y transformación de los recursos líticos dentro de grupos neandertales””, Reference: HAR2013-48784-C3-3-P. It is also part of a Spanish government grant entitled: Ayudas del Programa de Formación del Profesorado Universitario (FPU), MECD.

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